Redefining Revolution in Engineering: Federal R&D in Computing, Information and Communications

NEEDHA 1997 Annual Meeting

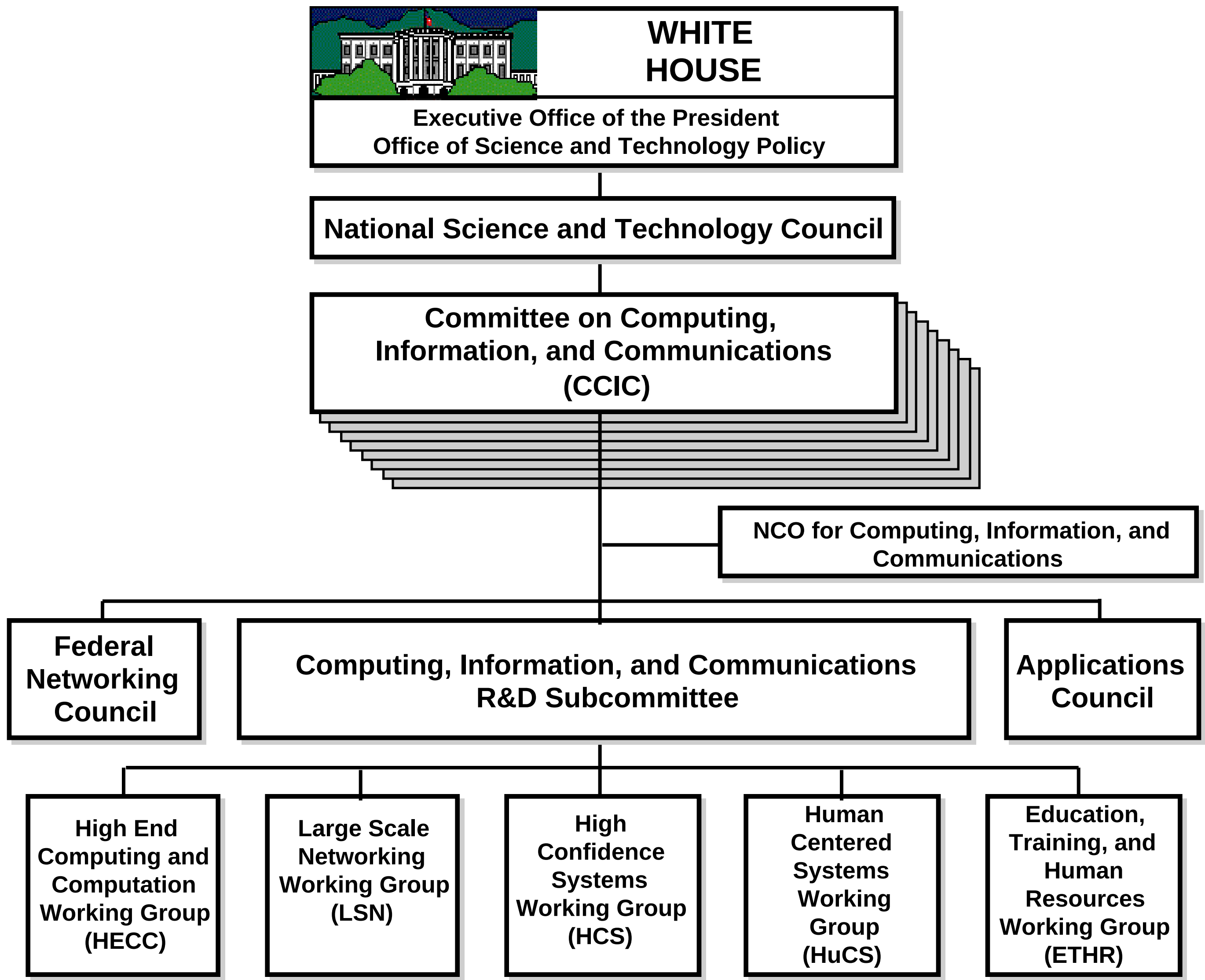
17 March 1997

John C. Toole

Director

National Coordination Office for
Computing, Information, and Communications

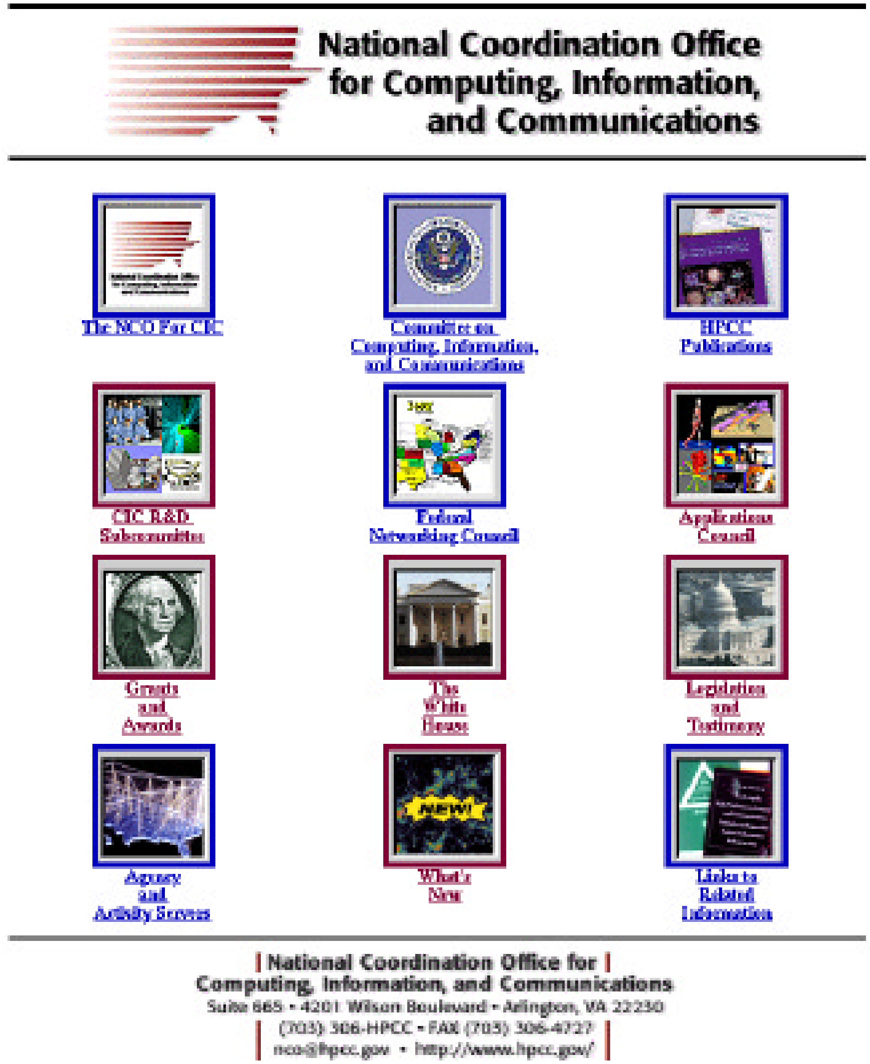
Organizational Structure



NCO for CIC

- Supports CCIC and its interagency R&D programs
- Coordinate preparation of planning, budget, and assessment documents
- Central point of CCIC contact to U.S. Congress, Federal agencies, state and local organizations, foreign organizations, academia, industry, and the public
- All interagency publications and information available at

  http://www.hpcc.gov



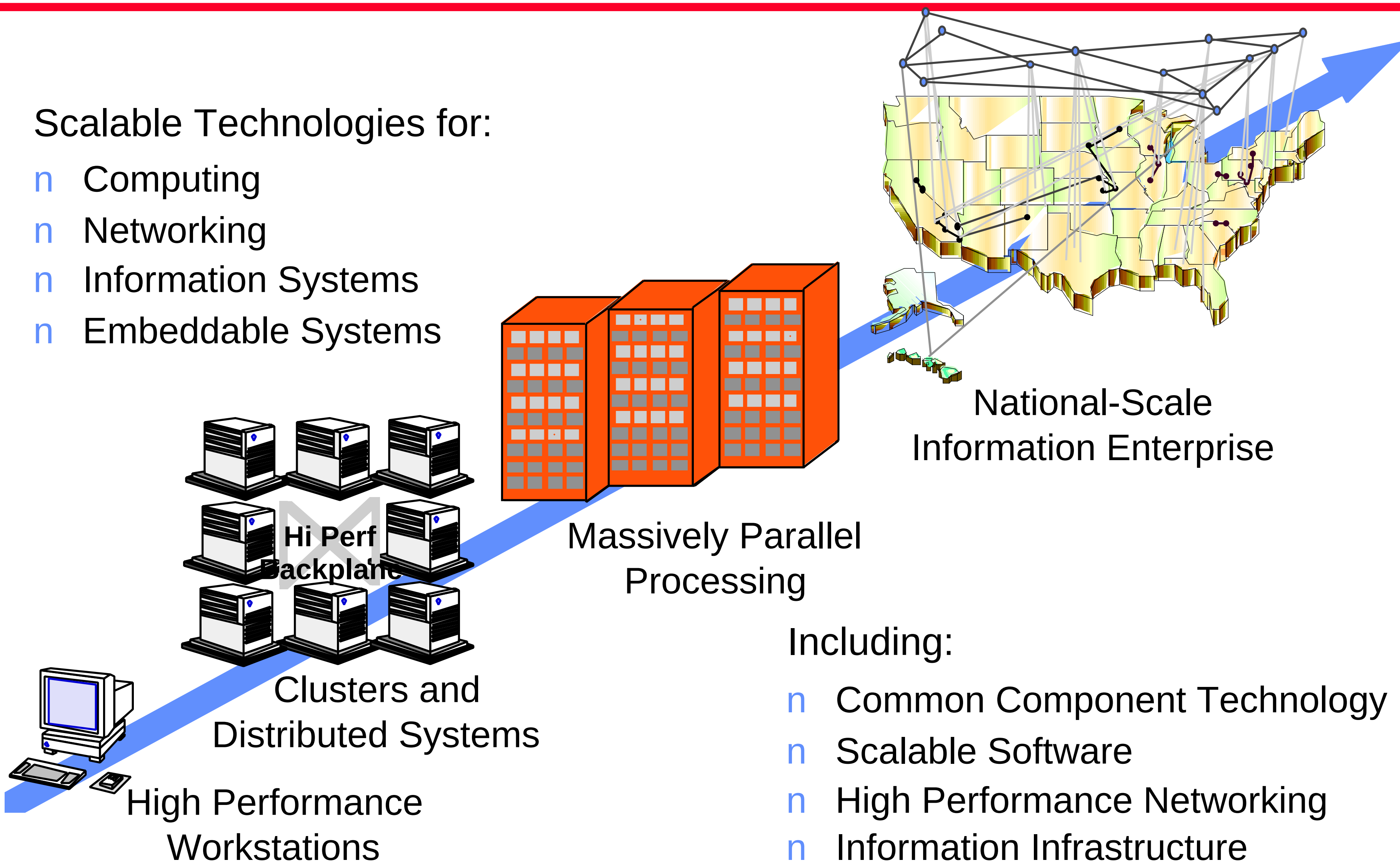
“Crises” and Opportunities

- Downsizing, Funding Environments
- Vector Processing
- Parallel Processing
- Scalable Technology
  - Trickle down?
  - Trickle up?
  - Commodity Components
- Markets have seen:
  - Monopolistic Periods
  - Competitive, Startup Periods
  - Shakeouts
- International Competition & Trade

A Recurring Vision (1993-1994)

Scalable Technologies for:

- Computing
- Networking
- Information Systems
- Embeddable Systems



Including:

- Common Component Technology
- Scalable Software
- High Performance Networking
- Information Infrastructure

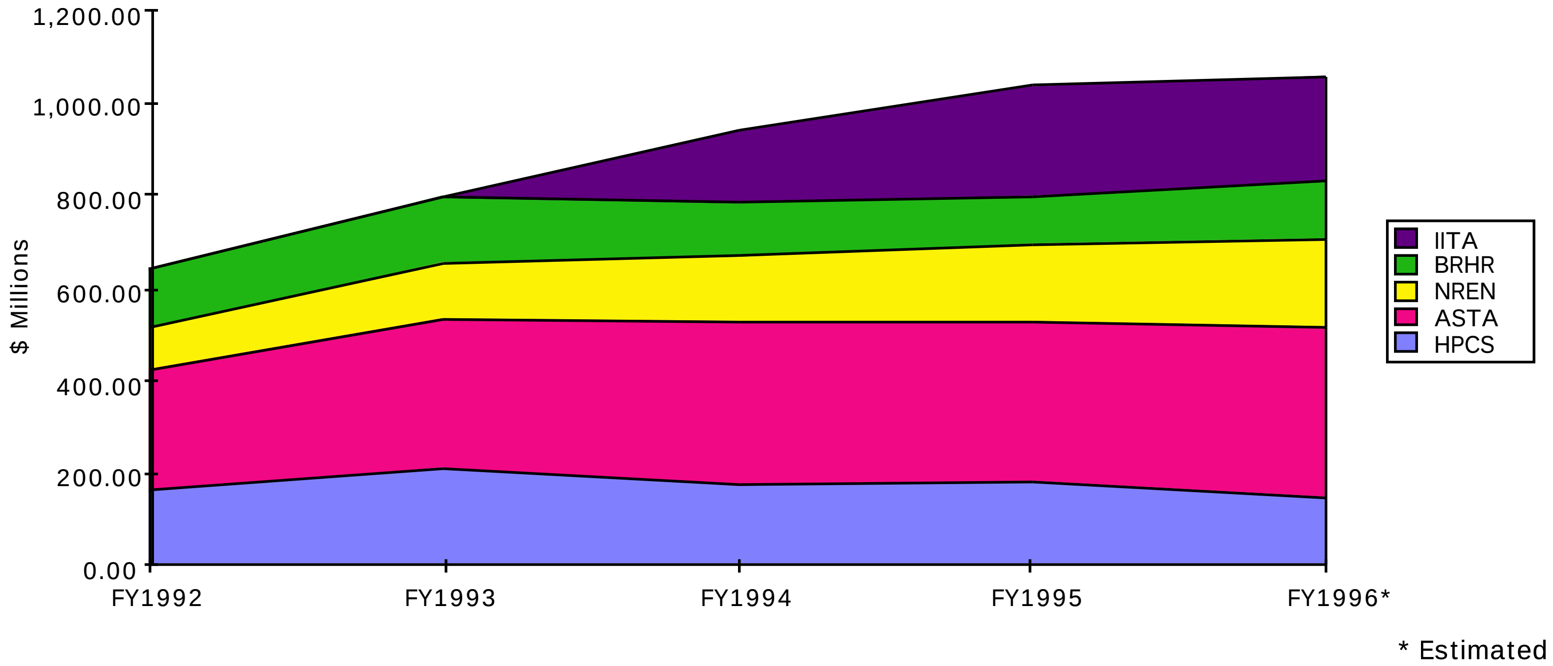
HPC Food Chain

- Basic materials, physics, math, etc.
- Microelectronics
- Component computing technologies (hardware, software)
- Computing system technologies
  - Systems
  - Compilers, debuggers, performance evaluation tools, etc.
- Integrated experimental systems
- A rich world of applications!

History of the Federal HPCC Program

- The Federal HPCC Program:
  - Chartered by Congress FY 1992 through FY 1996 with the High Performance Computing Act of 1991
  - Focused on:
    - High Performance Computing Systems
    - Advanced Software Technology and Algorithms
    - National Research and Educational Network
    - Information Infrastructure Technology and Applications
    - Basic Research and Human Resources
  - Was coordinated through the High Performance Computing, Communications, and Information Technology (HPCCIT) Subcommittee and NCO

Estimated Federal HPCC Program "Actual" Dollars by Components



Federal HPCC Program Contributions

- Scalable parallel systems
- Enabling technologies for workstations, distributed systems
- Microkernel operating systems
- Internet networking technology
- Information infrastructure, including early WWW browsers
- Research for Digital Libraries
- Gigabit testbeds
- Supercomputer Centers
- Grand Challenge Applications
- National Challenge Applications
- Mission applications: e.g., national security, medicine, environment, and education

Participating Agencies

- Defense Advanced Research Projects Agency (DARPA)
- National Science Foundation (NSF)
- Department of Energy (DOE)
- National Aeronautics and Space Administration (NASA)
- National Institutes of Health (NIH)
- National Security Agency (NSA)
- National Institute of Standards and Technology (NIST)
- Department of Education (ED)
- Department of Veterans Affairs (VA)
- National Oceanic and Atmospheric Administration (NOAA)
- Environmental Protection Agency (EPA)
- Agency for Health Care Policy and Research (AHCPR)

CCIC Strategic Planning - Phase II

(February 1997)

Discussions/Feedback:

- **CISE Advisory Group**
- **AEA**
- **HPCC Consortium**
- **CASC**
- **IEEE**
- **PCAST**
- **Computer Science Tech Board**
- **Electronic Subcommittee**
- **Pasadena II Workshop**
- **CSPP**
- **XIWT**
- **RCI**
- **ACM**
- **CRA**
- **SURA**

Sept 94 — CIC Strategy Group Established

Feb 95 — CIC Plan Published

May 95 — FY 1996 Federal HPCC Program Documents

July 95 — CIC Workshop - 6-7 July

Aug 95 — CIC Forum Report for Review

Mar 96 — FY 1997 President's Budget

Sept 96 — CIC R&D Review Budgets Submitted

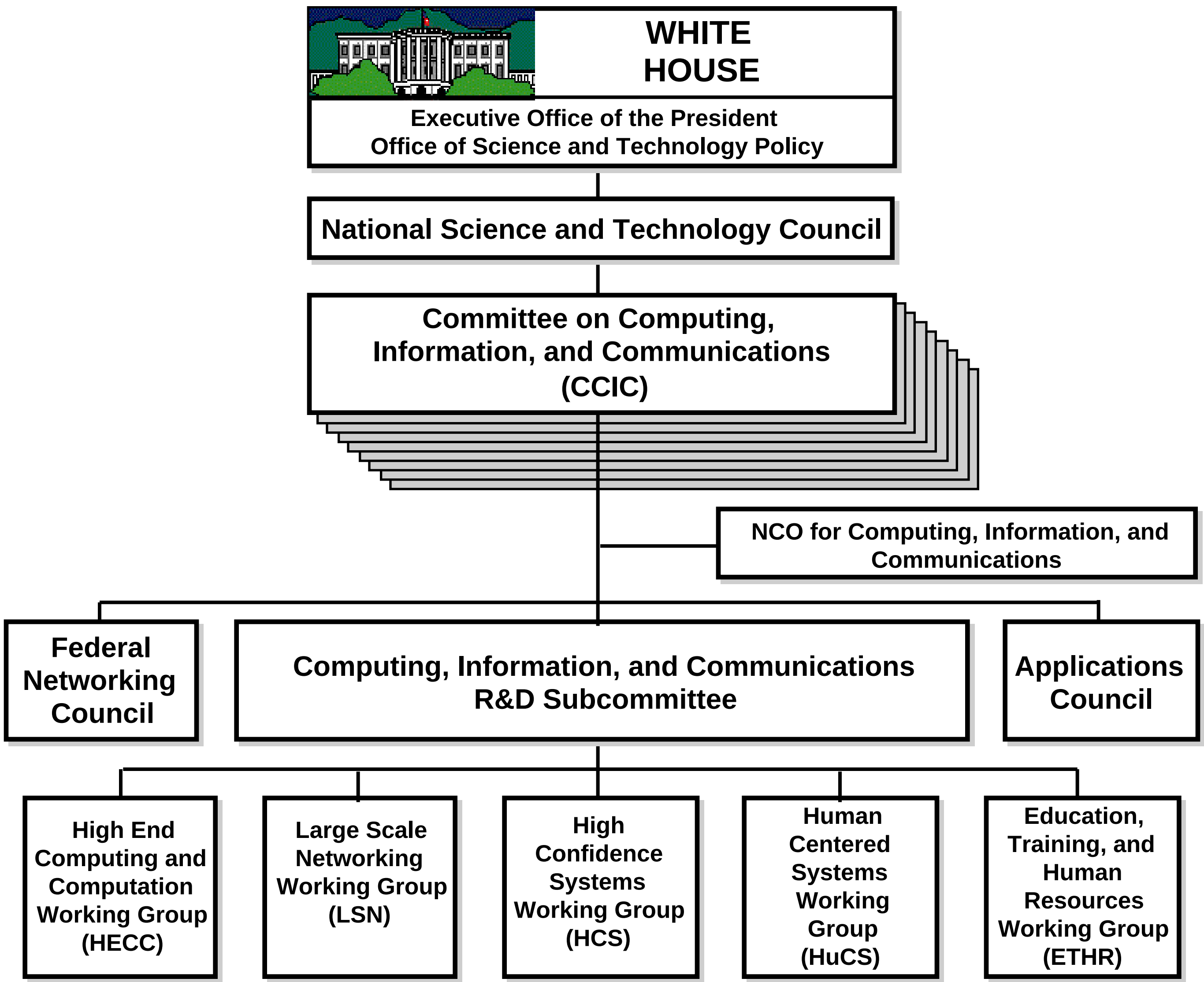
Feb 97 — FY '98 Pres Budget

Feb 97 — First Presidential Advisory Cmte Mtg.

New CCIC R&D Structure

- Broader collaborative R&D investments
- Five Program Component Areas (PCA)
  - High End Computing and Computation
  - Large Scale Networking
  - High Confidence Systems
  - Human Centered Systems
  - Education, Training, and Human Resources
- Each PCA will:
  - Span areas in which multiple agencies have interests/programs
  - Include hardware, software, algorithms, and applications
  - Focus on specific research goals, ensure adequate investments, and maintain necessary budget visibility
- Technology R&D may span multiple PCAs

Organizational Structure



Draft FY 1997 HPCC Crosscut Budget Request (Dollars in Millions)

Agency	HECC	LSN	HCS	HuCS	ETHR	TOTAL
DARPA	72.7	106.4	10.0	103.6		292.7
NSF	129.2	72.3	1.2	57.8	19.1	279.6
DOE	86.0	14.8		14.9	3.5	119.2
NASA	87.4	14.6	1.6	5.5	5.3	114.4
NIH	23.4	26.5	4.2	27.2	5.9	87.2
NSA	30.4	3.5	7.3			41.2
NIST	4.0	2.5	3.4	13.7		23.5
VA	1.0	9.4	2.3	1.8		14.5
ED				11.4	6.6	18.0
NOAA	4.3	2.7		0.5		7.5
EPA	6.6			0.6		7.2
AHCPR				4.2		4.2
TOTAL	445.0	252.6	30.0	241.2	40.4	1,009.2

Draft FY 1998 HPCC Crosscut Budget Request (Dollars in Millions)

Agency	HECC	LSN	HCS	HuCS	ETHR	TOTAL
DARPA	84.8	89.2	9.4	137.9		321.3
NSF	132.9	79.2	0.9	60.2	21.0	294.2
DOE	90.8	48.8		9.9	3.0	152.5
NASA	90.9	25.1	2.8	4.9	4.7	128.4
NIH	23.7	28.2	4.1	29.3	6.4	91.7
NSA	26.4	2.2	7.2			35.8
NIST	4.0	5.5	3.4	13.6		26.5
VA		7.4	5.4	9.2		22.0
ED					12.0	12.0
NOAA	4.3	2.7		0.5		7.5
EPA	5.4			0.8		6.2
AHCPR				5.5		5.5
TOTAL	463.2	288.3+	33.2	271.8	47.1	1,103.6*

+ The requested FY 1988 LSN budget includes funds for the Next Generation Internet (NGI) Initiative. It also reflects the transition of DARPA's mature technology research from networking development to networking applications. For example, DARPA's FY 1998 allocation for HuCS includes $21M transferred from the FY 1997 networking research budget.

* These totals vary slightly from the President's HPCC Budget. For example, funding for the Department of Transportation, one of the candidate agencies for participation in CIC R&D activities, is not included.

Presidential Advisory Committee Members

Co-Chairs: Bill Joy, *Sun Microsystems*
Ken Kennedy, *Rice University*

Eric A. Benhamou, *3Com Corporation*

Vinton Cerf, *MCI Communications*

Ching-chih Chen, *Simmons College*

David Cooper, *Lawrence Livermore National Laboratory*

Steven D. Dorfman, *Hughes Telecomunications and Space Company*

Robert Ewald, *Cray Research*

David J. Farber, *University of Pennsylvania*

Sherrilynne S. Fuller, *University of Washington*

Hector Garcia-Molina, *Stanford University*

Susan L. Graham, *University of California, Berkeley*

James N. Gray, *Microsoft Research*

W. Daniel Hillis, *Walt Disney Imagineering*

David C. Nagel, *AT&T Labs*

Raj Reddy, *Carnegie Mellon University*

Edward H. Shortliffe, *Stanford University School of Medicine*

Larry Smarr, *National Center for Supercomputing Applications*

Leslie Vadasz, *Intel Corporation*

Andrew J. Viterbi, *QUALCOMM Incorporated*

Steven J. Wallach, *Hewlett-Packard, Convex Technology Center*

First Advisory Committee Meeting

- February 27-28, 1997, at National Science Foundation
- Briefings by
  - Office of Science and Technology Policy
  - Committee on Computing, Information, and Communications
  - Computing, Information, and Communications R&D Subcommittee
  - Federal Networking Council
  - Applications Council
- Met with Vice President
- Formation of subcommittees
- Briefing materials available at:

  http://www.hpcc.gov/advisory-committee

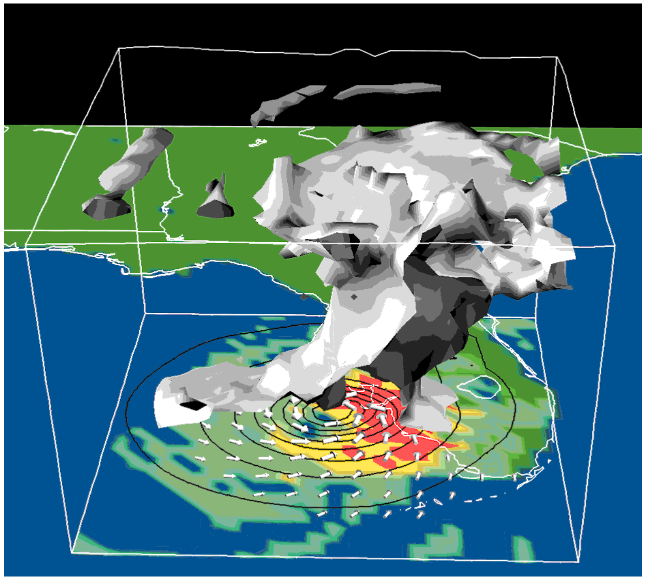
Presidential Advisory Committee

- President Clinton signed an Executive Order in February
- Establishes the Advisory Committee on High Performance Computing and Communications, Information Technology, and the Next Generation Internet:
  - Non-federal members; community representatives from research, education, and libraries; network providers; and critical industries
  - Provides the National Science and Technology Council, through the Director, OSTP, with advice and information on high-performance computing and communications, information technology, and the Next Generation Internet
  - Terminates two years from date of Executive Order, unless extended by the President
- 21 Members have been appointed, including two Co-Chairs
  - Bill Joy, Sun Microsystems
  - Ken Kennedy, Rice University

High End Computing and Computation

- System software and tools
- Application development environments
- Fast, efficient algorithms for simulation, modeling and visualization
- System architectures
- Device technologies
- Interconnection technologies
- I/O, and multi-level data storage
- Laboratory demonstration prototypes
- Advanced simulation of physical phenomena and other grand challenge applications

Examples of High End Computing and Computation Projects



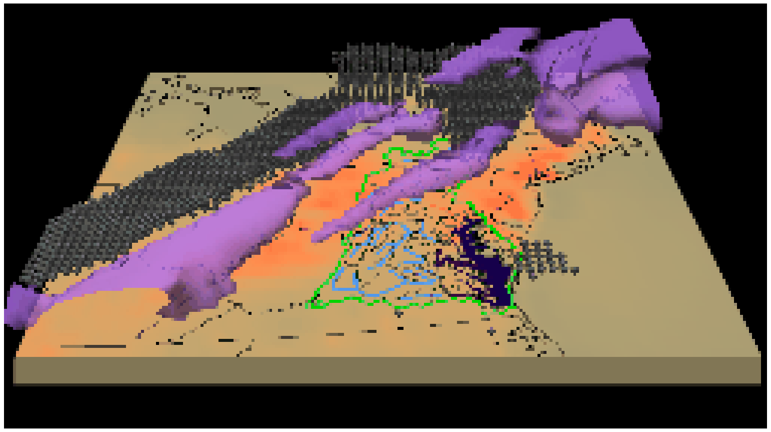
Tropical Storm Gordon, just before becoming a hurricane

GFDL/NOAA Hurricane Model

- Hurricane Prediction System
- 1993 - Run in semi-operational test mode
- 1994 - Part of National Centers for Environmental Prediction operational hurricane forecast suite
- 1995 -Model became fully operational
- 1996 - High resolution models run on highly parallel systems for the Centennial Olympics
- Run for tropical systems at all development stages
- Found to be in top performance group for forecasts out to 36 hours and superior to all other forecast models at 48 and 72 hours

Environmental Modeling

- Parallel logarithms used to model movement of groundwater contaminants
- Numerical simulations to estimate impact of decades of toxic pollution
- Research on nonlinear optimization and control techniques used to minimize groundwater cleanup costs
- Regional Particulate Model (RPM) developed to monitor air quality by region
- Parallel computing used to quantify potential effects of earthquakes on new construction and to assist in creating new safety codes



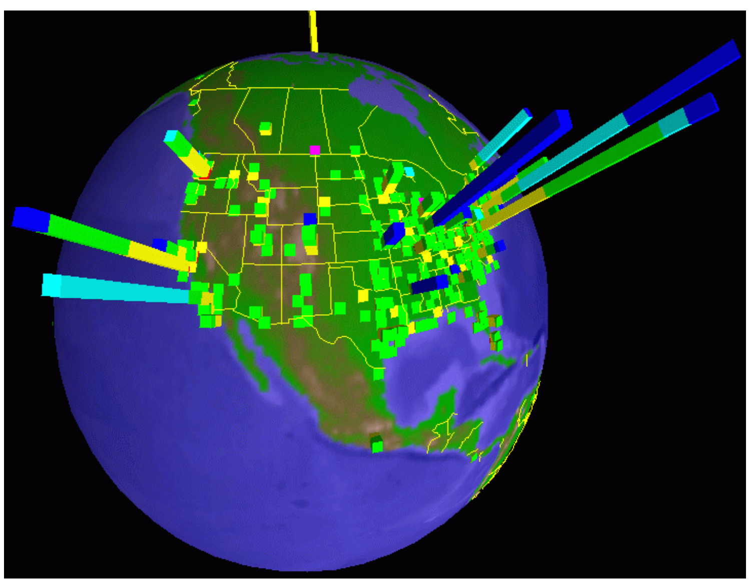
Simulation of nitrogen deposition to the Chesapeake Bay and surrounding areas during a rainstorm.

Large Scale Networking

- Fast, efficient routing and enhanced network service
- High performance networking research infrastructure
- Design and scalability issues of large multi-node networks
- Very high performance network components and testbeds
- Network-centric computing including system software and program development environments for scalable distributed systems
- National Challenge-class application drivers such as:
  - Distributed information acquisition tools
  - Digital library technologies
  - Computer-based patient records
  - Electronic commerce

Examples of Large Scale Networking Projects

- I-Way was an extensive networking project introduced at Supercomputing ’95
- Experimental, high performance network
- Linked over a dozen high performance computers and advanced visualization machines
- Used as testbed to prototype:
  - Teraflop-class wide area computing
  - An advanced application development resource

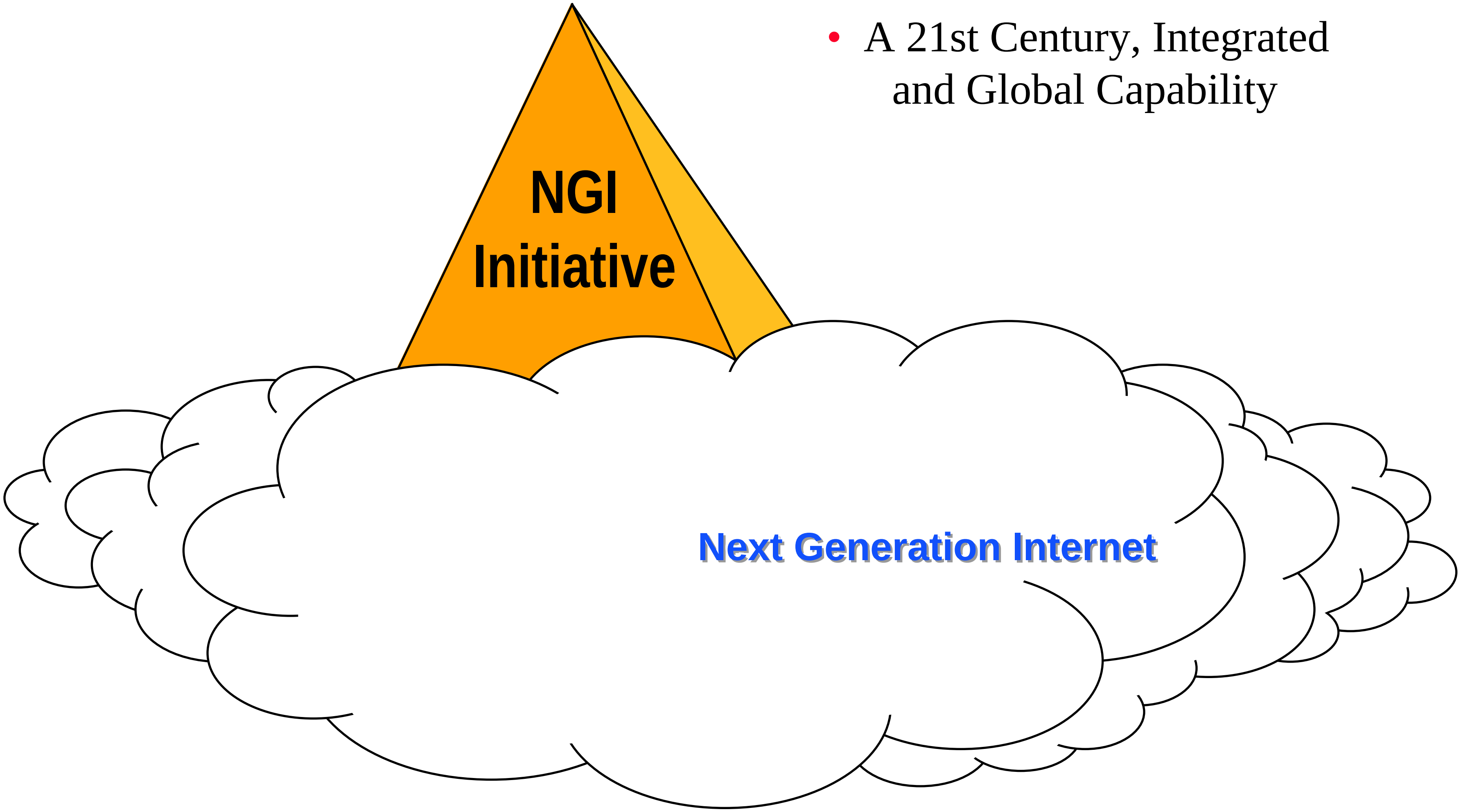


- Begun with development of ARPANET in late 1960s
- Network infrastructure created with NSFNET in 1985
- Development of Mosaic browser in early 1990s
- Community level service turned over to private sector Internet service providers in April 1995
- Unprecedented Internet growth stimulated by HPCC R&D and from public and private investment

Next Generation Internet Initiative

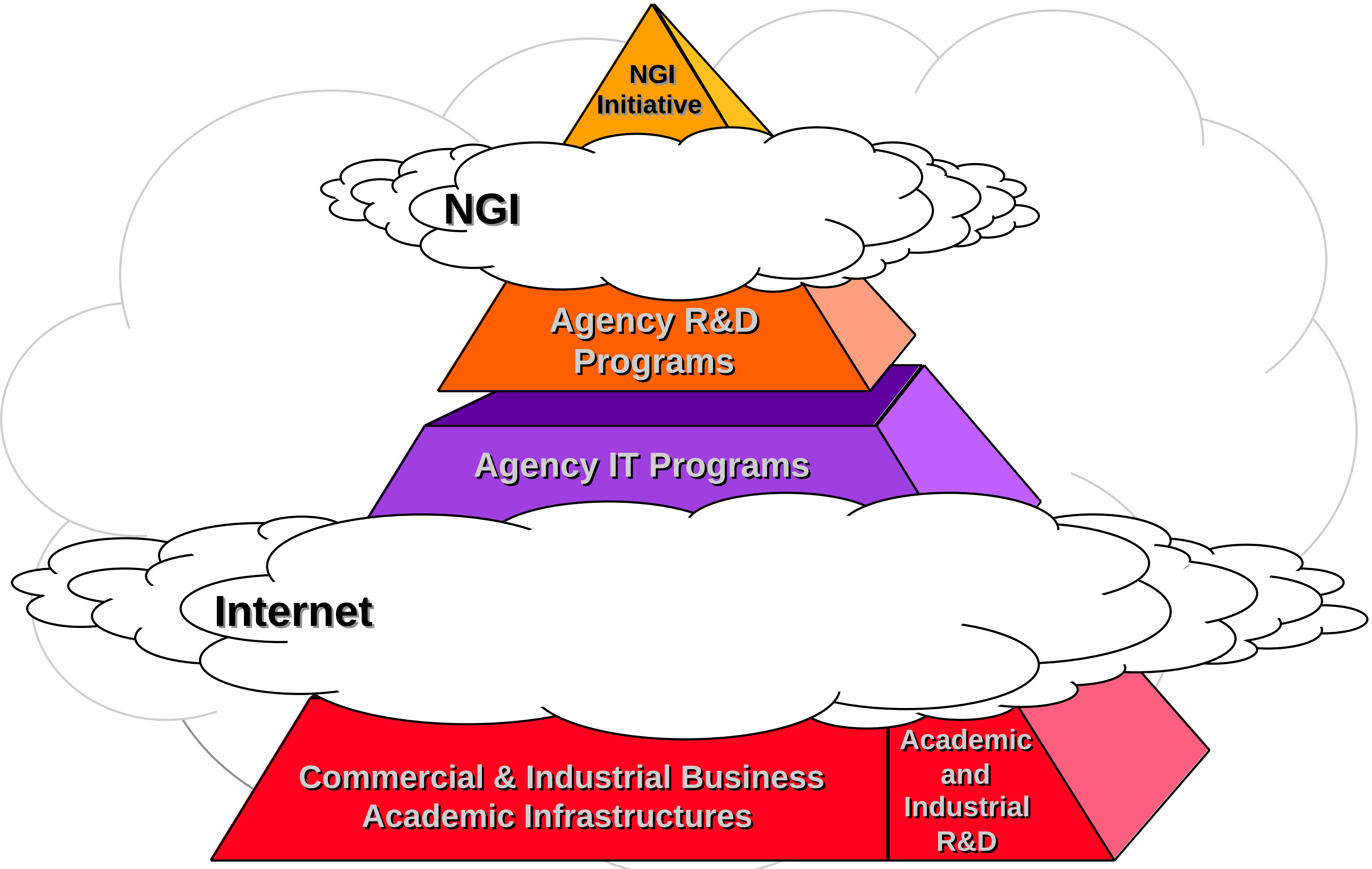
Goals	Metrics
1. Connect universities, national labs and research institutions with high-performance networks: • At least 100 organizations at speeds of 100 times today's Internet • At least 10 organizations at speeds of 1000 times today's Internet	end-to-end performance; number of institutions connected
2. Promote experimentation with the next generation of networking technologies	quality of service; adoption of technologies by commercial Internet
3. Demonstrate new applications that meet important national goals and missions	100+ high importance applications; value of applications in testing network technologies

The NGI Vision

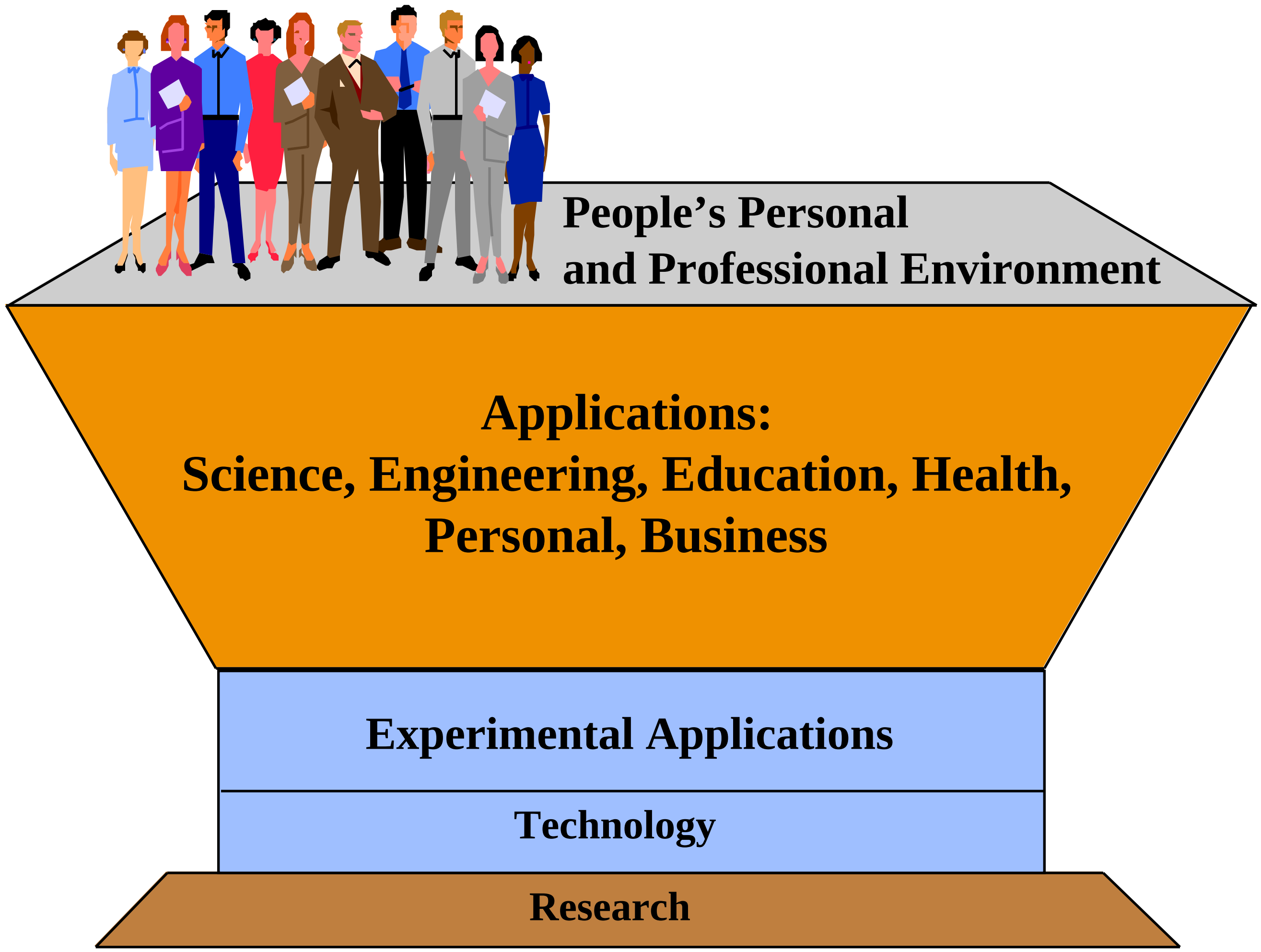


- A 21st Century, Integrated and Global Capability

NGI: "The Programs"



But We Are Really Impacting People!

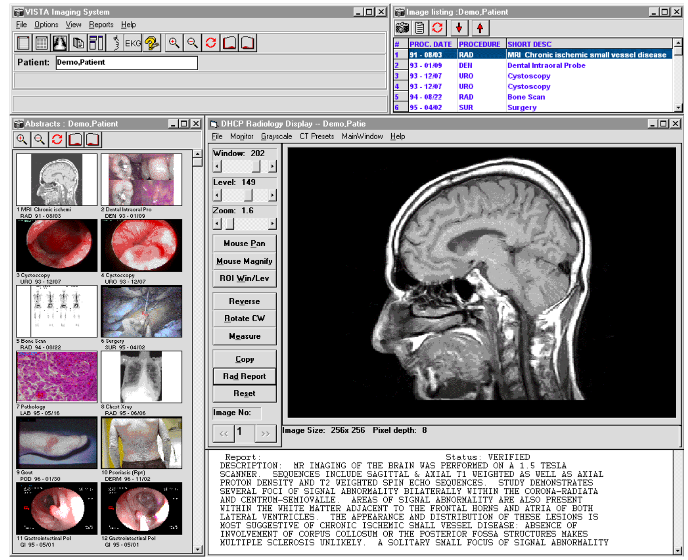


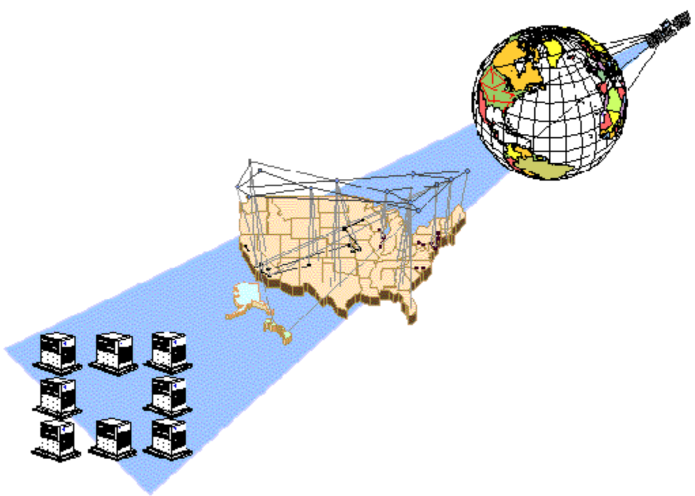
High Confidence Systems

- High Confidence Computing
- High Confidence Networking
- Encryption, Assurance, and Integration
- Large Scale Systems
- Testing Methodologies and Techniques

Examples of High Confidence Systems Projects

- Merging of computerized patient record systems and telemedicine systems in way that assures integrity and confidentiality of records



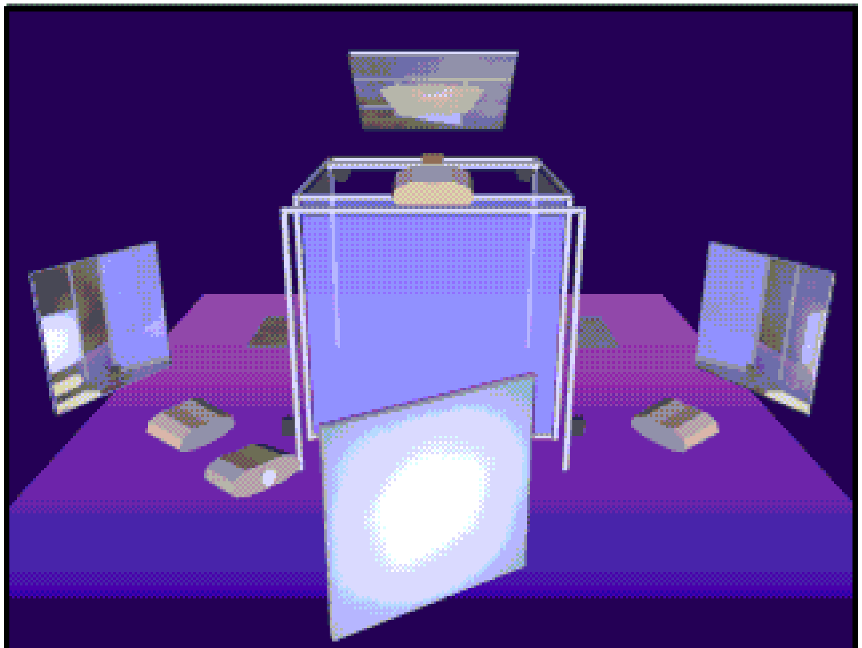


- Critical technologies to ensure global, survivable, secure networks that support high performance distributed computing and information systems with dynamic topologies

Human Centered Systems

- Collaboration technologies and applications, including collaboratories, distributed multi-media, middleware, and control of remote instruments
- Multi-modal human-system interactions
- Document understanding and multilingual language technology
- Information agents and environments
- Virtual reality environments and applications
- Knowledge repositories for information access, management, and applications
- Interdisciplinary research in human cognition applied to tools for content recognition and human-system interaction

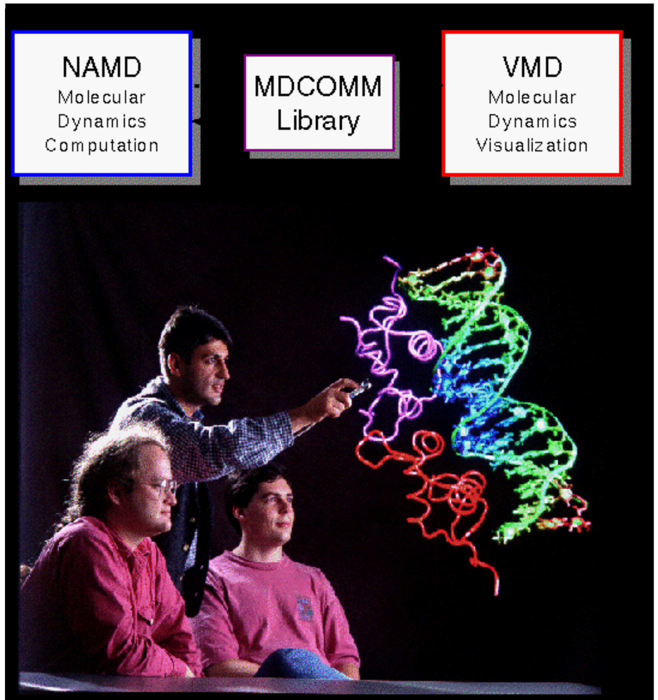
Examples of Human Centered Systems Projects



Surround-screen, surround-sound, projection based virtual reality systems (CAVE)

- Visualization, virtual reality, and human-machine interfaces
- Ability to generate, collect, and manipulate vast amounts of data
- Development of a prototype "omnifocus" electronic camera

- Health care and biomedical imaging
- Enhance patient care, improved drug design, and broaden access to medical information



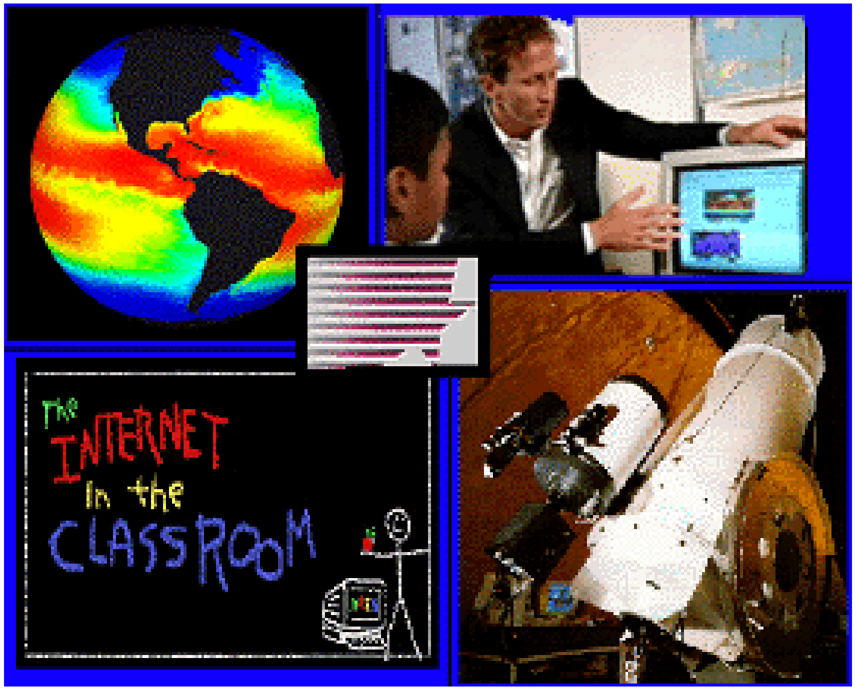
Prototype visual medical chart integrating multi-disciplinary medical images

Education, Training, & Human Resources

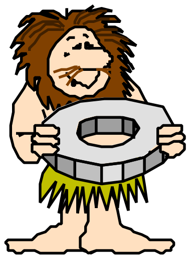
- Advanced technologies for high quality, affordable software learning tools
- Information based models of educational systems and learning productivity
- Research on learning and cognitive processes
- Demonstrations of innovative technology and networking applications

Examples of Education, Training, and Human Resources Projects

- Math and Science Gateway and Gateway for Educators provide web site with access to science and math resources for students and teachers
- Enable design and deployment of multimedia modules used in interactive tutorials
- HorizonNet demonstrates low cost Internet access for a school consortium
- Develop interactive and visualization tools for special educational projects



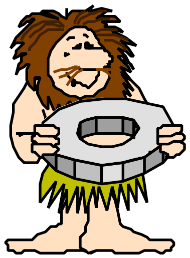
Users of High Performance Computing Technologies



The First 10

- Tolerate anything to find a solution

Users of High Performance Computing Technologies



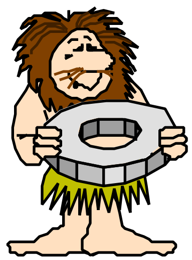
The First 10

- Tolerate anything to find a solution

The Next 100

- Presume stability, but with driving needs tolerate some pain

Users of High Performance Computing Technologies



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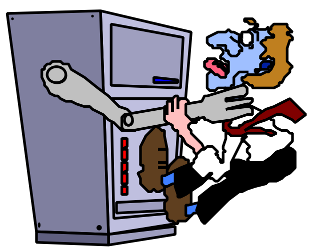


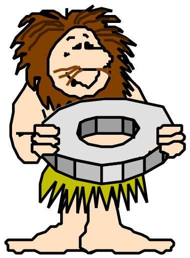
The Next 100

- Presume stability, but have driving needs and tolerate some pain

The Next 1,000

- Want stability, might test the water,but only in their own discipline

Users of High Performance Computing Technologies



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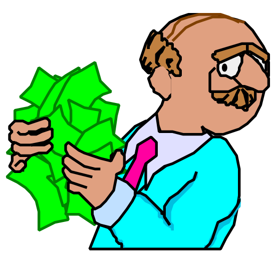

The Next 10,000,000

- Want everything...and for free

A Few Challenges

- Role of algorithms, mathematics, science, and engineering in the 21st century
  - Evolving but maintaining the fundamentals
- Computer, computational, mathematical, and physical science communities
  - The world is now networked, yet barriers need to be broken
- Innovation in very complex systems
  - Cost, size, complexity, and metrics
  - Validations
- The next three generations
  - Perhaps within our lifetime!

Revolutions

- Computing, networking, and distributed systems providing a new baseline for disciplined, knowledge engineering
- New paradigms in engineering
  - Computational experimentation
  - Computational phenomena
- Roles of mathematics and physical science
  - Physical science, mathematics, and theories DO matter
  - Applied computational science and theoretician is changing

What's Important?

- Sustained investments for the long term
  - Commitment to Science and Engineering
- Innovative Technology Transition
- A new generation of partnerships between
  - Government
  - Industry
  - Academia
- People
  - Users
  - Managers
  - Scientists and Researchers